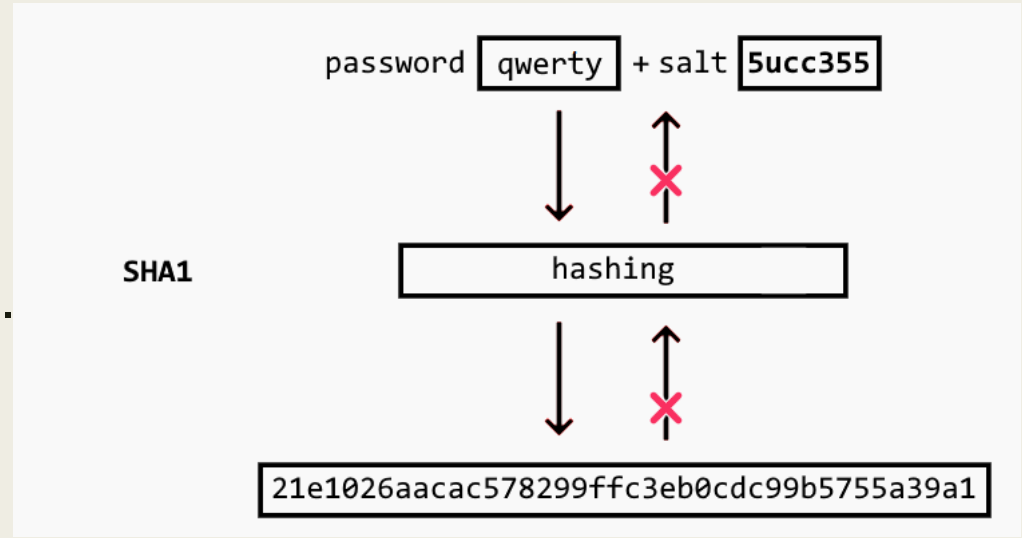
# RAINBOW TABLE ATTACK DEMONSTRATION

# What Is Password Hashing ?

- Password hashing converts a password into a fixed-length value.
- The output is called a **hash**.
- The same password always produces the same hash.
- Hashing is a **one-way function** and cannot be reversed.
- Hash functions are deterministic.
- Hash functions are designed to be computationally efficient but secure.
- ➞ Passwords are stored as hashes, not as plain text

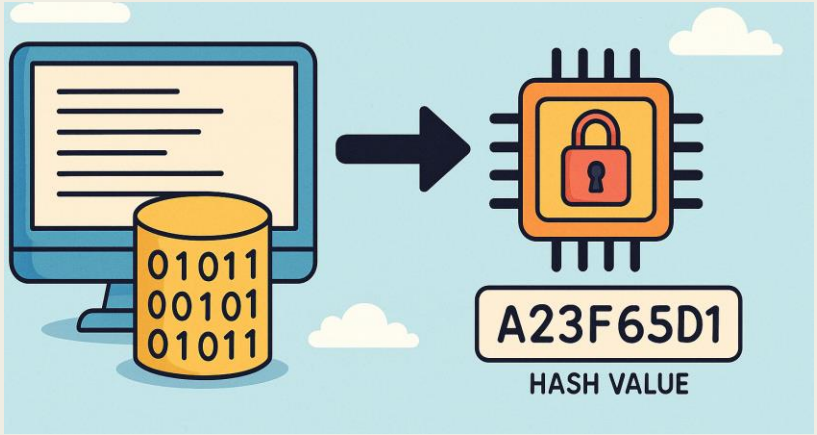


# Password Hashing Properties

- Deterministic
- Fixed length output
- One-way function
- Avalanche effect

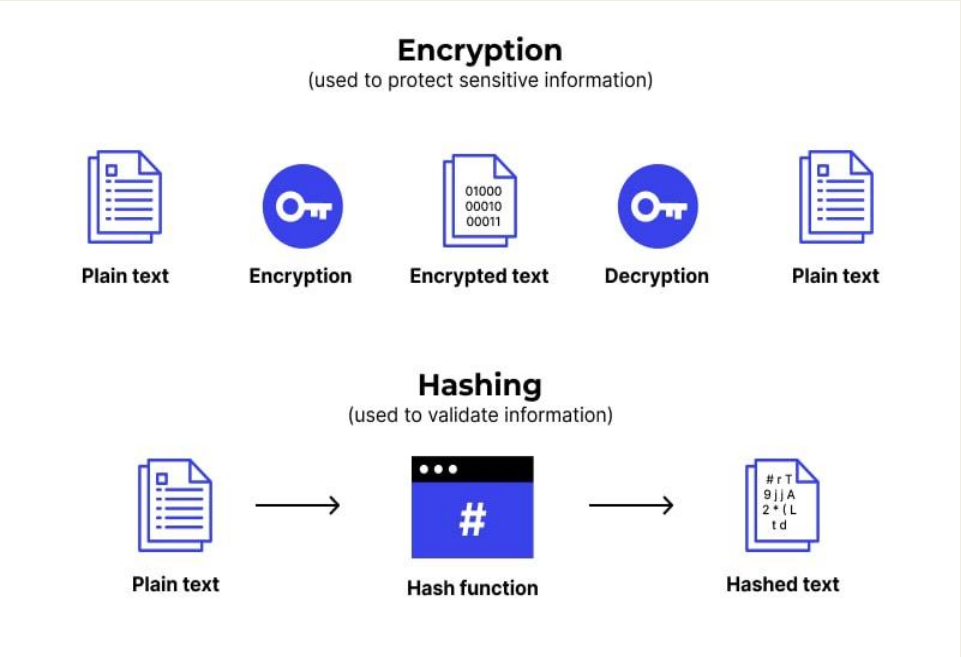
# Why Systems Use Hashing ?

- Protects passwords if the database is compromised.
- Prevents attackers from reading original passwords.
- Prevents system administrators from knowing user passwords.
- Reduces damage caused by data breaches.
- Essential for secure authentication systems.



# Hashing vs Encryption

- **Hashing:**
- One-way process.
- Cannot be reversed.
- Used for password storage.
- Encryption requires secure key management, hashing does not.
- **Encryption:**
- Two-way process.
- Can be reversed using a key.
- Used for data confidentiality.
- ➞ Passwords must be hashed, not encrypted.



# What Is a Rainbow Table Attack ?

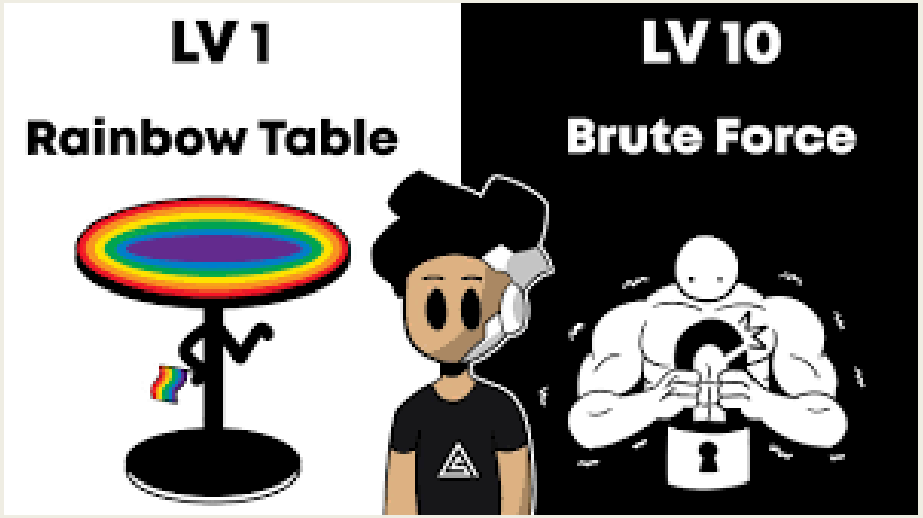
- A rainbow table is a precomputed database of passwords and hashes.
- Attackers match stolen hashes against the table.
- No need to guess passwords during the attack.
- Faster than brute force attacks.
- Targets weak hashing implementations.
- Rainbow tables rely on the predictability of hash outputs.

# Why Rainbow Table Attacks Are Effective

- Hashes are computed in advance.
- Saves time during the attack phase.
- Extremely fast compared to brute force.
- Effective against common and weak passwords.
- Works well on unsalted hash databases.
- Attack efficiency increases with fast hash algorithms.

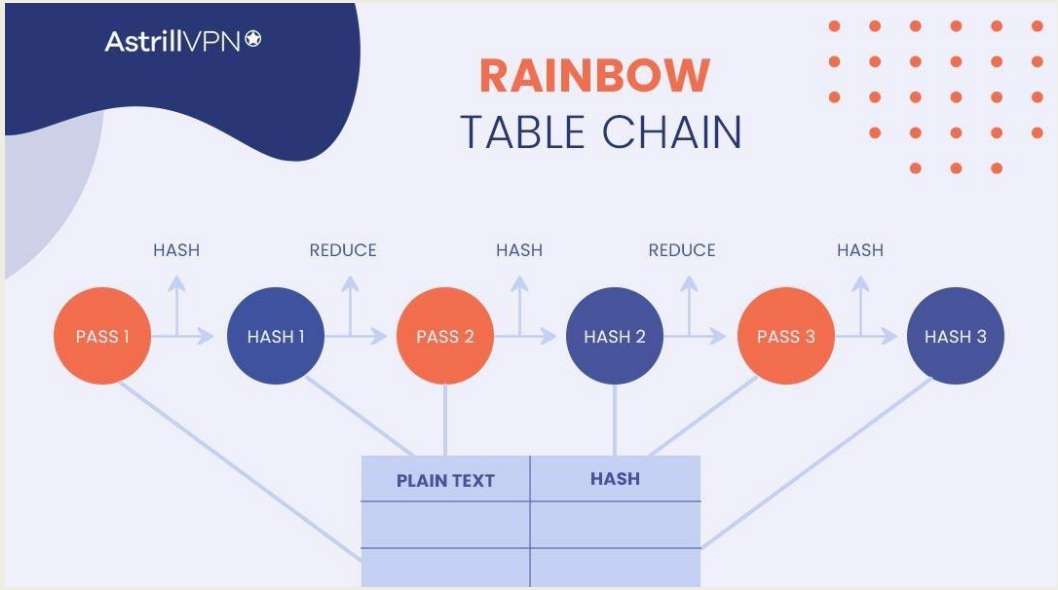
# Brute Force vs Rainbow Table

- **Brute Force Attack**:
- Tries all possible password combinations.
- Very slow for large password spaces.
- High CPU usage.
- No precomputation.
- **Rainbow Table Attack**:
- Uses precomputed hash tables.
- Very fast lookup.
- Requires large storage space.
- Limited to known password lists.
- Precomputation phase performed once.



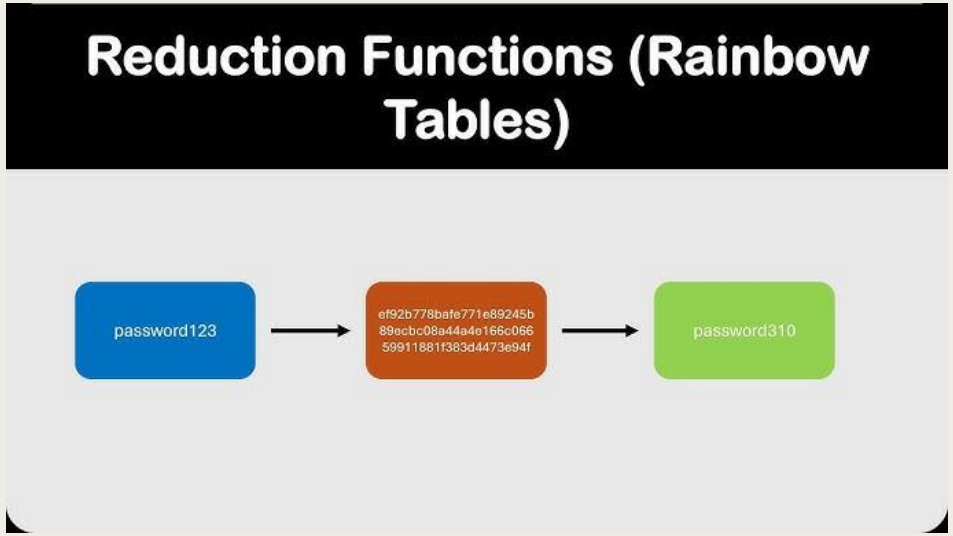
# How Rainbow Tables Work

- Generate a list of common passwords.
- Apply a hash function to each password.
- Store hash–password relationships.
- Use reduction functions to reduce storage.
- Compare stolen hashes with the table.



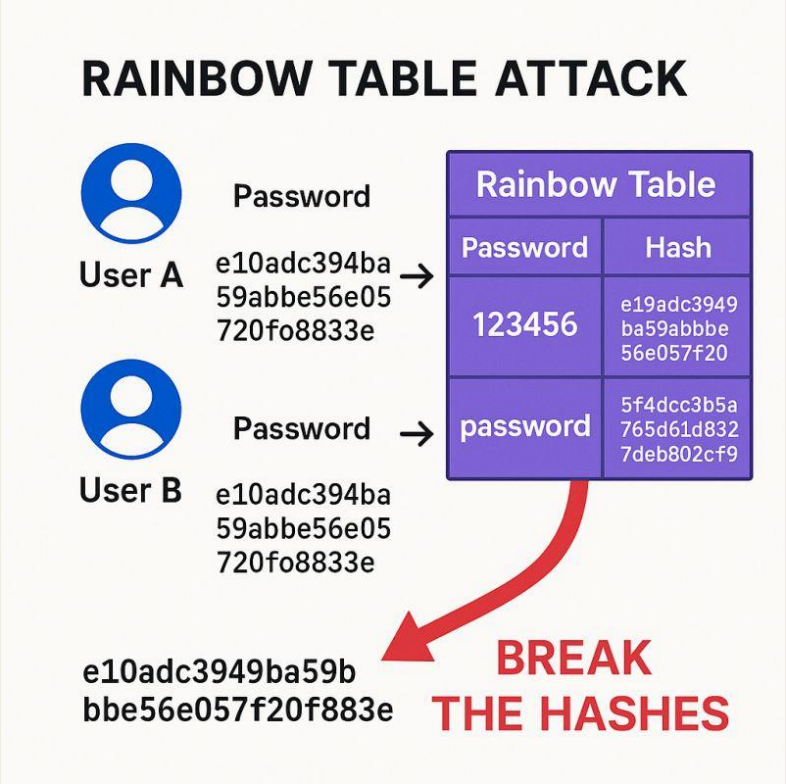
# Reduction Function Concept

- Reduction functions map hash values back to possible passwords.
- They do not reverse the hash.
- Used to form chains in rainbow tables.
- Reduce storage requirements.
- Improve efficiency of large tables.
- Reduction functions are not cryptographic functions.



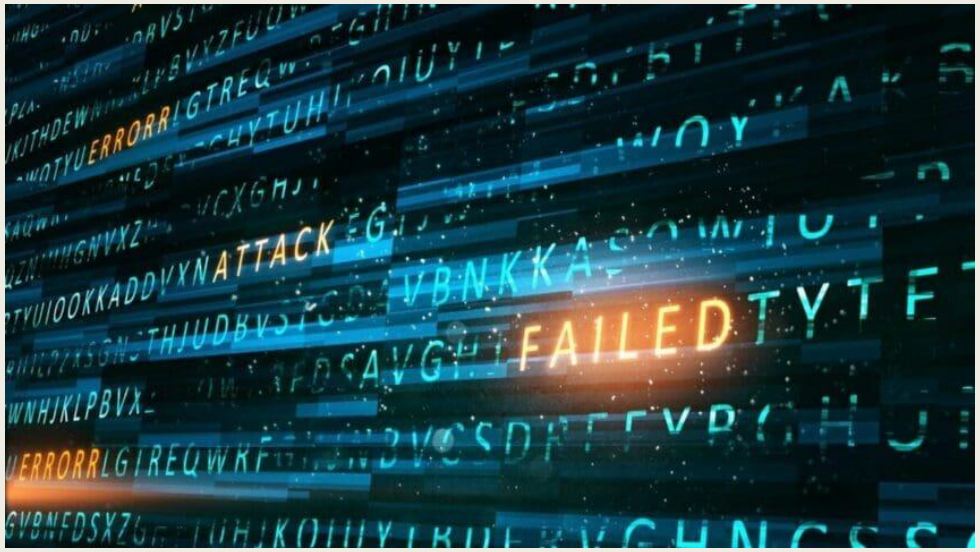
# Attack Scenario

- Attacker gains access to a database of hashed passwords.
- Hashes are extracted from the database.
- Each hash is searched in the rainbow table.
- If a match exists, the password is revealed.
- Attack succeeds without guessing.



# When Rainbow Tables Fail

- Strong and complex passwords.
- Long password length.
- Use of unique salts.
- Use of slow hashing algorithms.
- Modern password protection techniques.
- Use of key stretching techniques.



# Real-World Impact

- Older systems using MD5 or SHA-1.
- Databases without salting.
- Legacy systems with weak security.
- Past data breaches exposed hashed passwords.
- Motivated stronger password policies.
- Led to security standards recommending salted hashing.

# Limitations of Hashing Alone

- Hashing without salt is vulnerable
- Fast hash functions are dangerous
- Weak passwords reduce security
- Implementation matters

# Defense Against Rainbow Tables

- Add a unique salt to each password.
- Use slow hashing algorithms:
  - *bcrypt*
  - *scrypt*
  - *Argon2*
- Enforce strong password rules.
- Avoid outdated hash algorithms.
- MD5 and SHA-1 are deprecated for password storage.

# Conclusion

- Rainbow tables exploit weak hashing practices.
- Precomputation makes attacks extremely fast.
- Unsalted hashes are highly vulnerable.
- Salting and modern hashing defeat the attack.
- Security depends on correct implementation, not just algorithms.
- Secure password storage is essential.